Master's Thesis

Sopoong: a New Design Concept for Picnic Activity

Wooin Jang

Department of Creative Design Engineering

Graduate School of Creative Design Engineering, UNIST

2021

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A thesis submitted to
the Graduate School of Creative Design Engineering, UNIST
in partial fulfillment of the
requirements for the degree of
Professional Master of Design Engineering

Wooin Jang

July / 14th / 2021 of submission
Approved by

_____

Advisor
Yunwoo Jeong

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This certifies that the thesis of Wooin Jang is approved.

July / 14th / 2021 of submission

Signature

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Advisor: Yunwoo Jeong

Signature

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typed name: Huisung Lee

Signature

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typed name: Youngwoo Park

Signature

Executive Summary

Due to social distancing for COVID-19, people's desire for small outdoor activities outside of crowded cities is increasing. Among them, a picnic that can be conveniently done anytime, anywhere, unlike camping, are attracting attention. Accordingly, there will be several personal loads that may be needed during a picnic, and this thesis aims to develop a product that carries such personal luggage and furthermore, suggests a new way of carrying personal luggage in the future.

Investigate personal luggage carrying products and analyze limitations of them. There are hand carry type (basket handbag, box etc.) that should be carried by hand, cart type (trolley, wagon, etc.) that have wheels and are pulled by hand, and robot type that automatically transports objects by mechanical and electronic power. The limitations of the existing products were constraints of terrain when carrying luggage, inability to relieve the burden on the body from the weight, the weight of the product itself, and restriction of both hands.

Next, digital ethnography was carried out to verify the limitations of the existing luggage carrying products above and to find out new picnic experiences that can be provided in actual picnic situations. After collecting the raw data, five user behavior characteristics were derived through the affinity diagram.

Characteristics of a drone were paid attention as design insight that can reflect the derived user behavior characteristics. Smart picnic, which includes effective luggage carrying regardless of terrain, quick picnic spot searching and photo taking supporting, was set as the direction of the concept. Next, after calculating the thrust of the drone's motor and propeller, the concept was materialized through product sketching, modeling, and prototyping.

The picnic drone 'Sopoong' makes users free from the weight of luggage and supports smart picnics providing new experiences that existing products could not. Furthermore, it proposes a new method of future personal luggage carrying products using a drone.

Keywords: Picnic, Drone, Luggage Carrying, Digital Ethnography, Engineering Design

Contents

Tables

Figures

1

Introduction

1.1 Background

1.2 Necessity of the Research

1.3 Research Aim & Scope

1. Introduction

1.1. Background

Leisure is free time that free from responsibility for society, home or labor and taking a rest, refreshing oneself or expanding knowledge according to the participants' free will (Kim & Sim, 2004). As leisure time increases due to the five-day work-week system, the proportion of leisure time in our lives is increasing. A lot of attention is focused on what activities you participate in in your free time to increase your leisure satisfaction and further increase your life satisfaction (Huh & Choi, 2017). Leisure serves the individual as follows: Leisure helps to restore the body and mind exhausted from daily life and relieves boredom and stress. In addition, it has the functions of relaxation, entertainment, and self-development because it can form a new creative attitude in physical, emotional, and rational aspects, away from everyday thoughts and actions (Dumazedier, 1967). As such, as leisure activities expand from the basic role of rest to active activities for improving the quality of life such as hobbies and self-development, the types of individual leisure activities are gradually diversifying (Yang & Kum, 2009). A picnic is one of the activities that people have enjoyed from the past that can easily create the atmosphere of a trip without having to go far. Recently, a picnic is gaining popularity in various fields beyond SNS, not only related products but also famous brand marketing. Sharing short but small pleasures with family and friends in the quiet nature has attracted the interest of those who want a simple yet leisurely life. A Picnic has long been a common recreational activity in US and Europe. It is a popular leisure culture where you go to a scenic spot on a sunny day, sit down, eat food and play light games with your family, relatives, and friends. A Picnic was not very popular culture in Korea. However, since the 1980s, the number of picnickers near mountains or rivers has gradually increased, and recently, it is easy to see people enjoying a picnic in nearby parks (Im, 2007).

1.1.1. Definition of Picnic

Picnic stands for going out outdoors such as parks, lake, mountains, and shores for the purpose of rest, nature observation, or tour. The etymology of picnic first appeared in France in 1692 as the word ‘pique-nique’ and it is known that the English word ‘picnic’ has been around since 1748 (Lee J. , 2014). Picnic originally referred to a meeting of nobles who bring their own food and share it indoors from France. Separately, the custom of eating outdoors originated from eating outside while hunting. These customs were combined to form an enjoyment culture among the nobles in the mid-18th century, enjoying food while eating in parks and gardens. Outdoor dining, which was a custom of nobility, became one of the common daily lives as the civil bourgeois grew in the 19th century, as can be seen in Figure 1. In the modern era, picnic has become one of everyday life and has become a concept to go outdoors, eat and enjoy food. In addition to this, today's concept of picnic is a generic term for activities that are easily enjoyed outdoors on a day as a family or small gathering amid leisure boom. It does not include sports elements such as hiking, mountain climbing, and camping but includes recreational elements. The characteristic of picnic is to enjoy freely without being constraints of schedule or location.

Figure 1. Examples of Picnic Style by Era

1.1.2. Activities of Picnic

Picnic activities can also take place in urban environments with nice artifacts, but most of them take place in natural environments. Picnic activities can be broadly divided into three activities: ‘to watch’, ‘to eat,’ and ‘to move.’ ‘To watch’ includes 'viewing' to see wonderful scenery or natural scenery, and sightseeing activities to walk and appreciate nature (Lee J. , 2014). 'To eat' is taking a break and eating a food brought, and 'to move' includes walking, light exercise, outdoor recreational activities, and photography etc. Recently, as a feature of picnics enjoying outdoors, leisure hobbies such as cycling, swimming, and drone photography are also entering 'to-move' area of picnic.

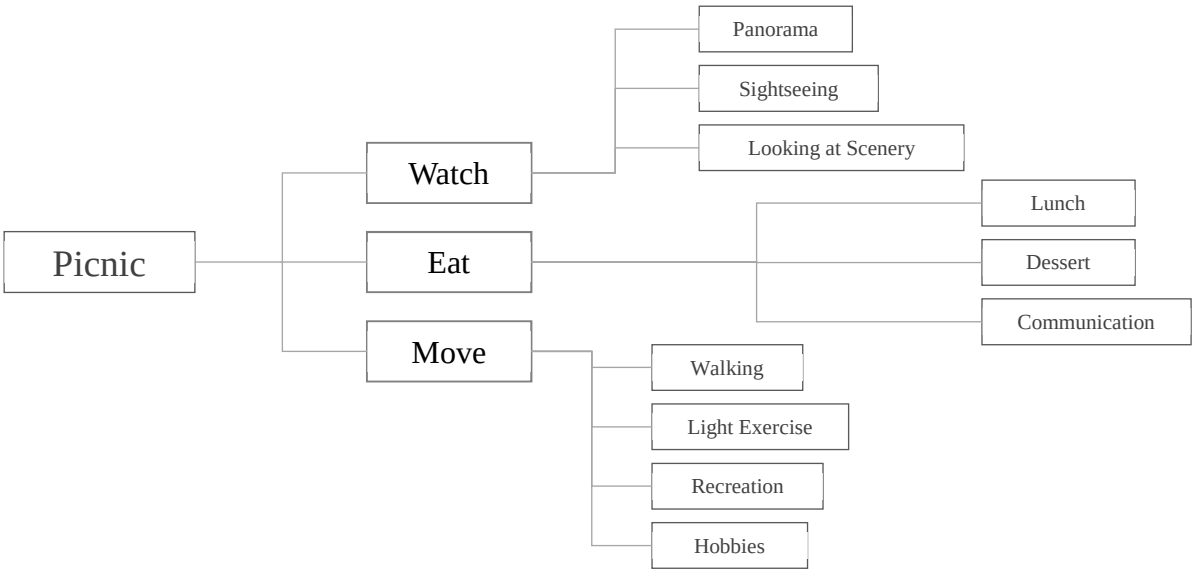

Figure 2. Activities of Picnic

1.1.3. Luggage of Picnic

As an extension of the previous picnic activities, objects or tools necessary for each activity are required. For example, when it comes to 'to eat', there are basically food and a lunch box to hold it. Additionally, fruits and beverages may be included. In the case of 'to move', when taking pictures activities, the camera and the tripod become the corresponding objects. As outdoor activities and recreation come into a picnic category, the kinds of luggage needed to be carried have diversified. This leads to an increase in the weight of luggage that users have to carry.

Figure 3. Personal Luggage of Picnic

1.2. Necessity of the Research

The needs to carry personal luggage for light outings or activities, including picnics, have existed from past time. To meet these needs, people have made and used tools such as sacks, bags, and carts. New types of products emerged using the technology of that era.

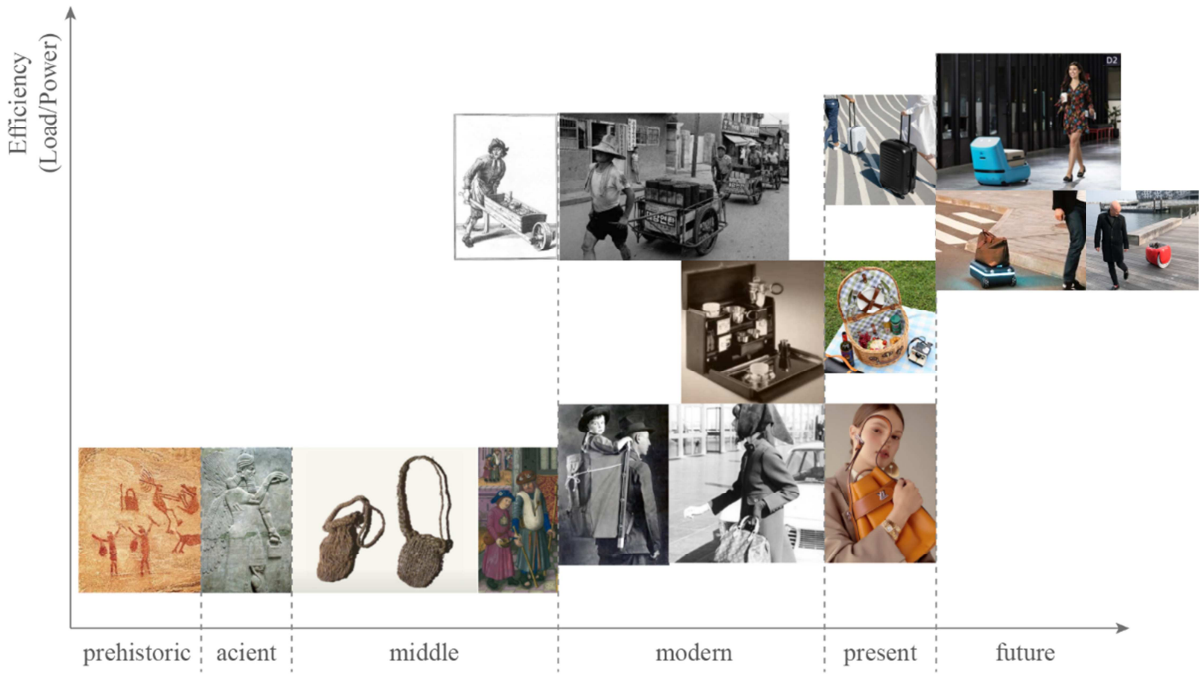

Figure 4. The Evolution of the Luggage-Carrying Tools over the Age

Figure 4 is a graph that outlines the changes in tools that help carry personal luggage from past to present. The horizontal axis represents the time from the past to the present, and the vertical axis represents the efficiency of lifting a lot of weight with little force. The tools started from the initial bag shape and developed into fashion, functional bags, picnic bags, etc. with their own characteristics. And, recently, it has developed into an autonomous driving robot that carrying personal luggage by using information and communication technology. In this direction of development, it can be thought that future tools will develop in the direction of getting the user's body free and reducing the load on the body. Additionally, constraints of terrain, which are limitations of wheels, remains an area to be addressed. In this study, a new type of personal luggage carrying product of the future will be proposed by focusing on applying new technology to the design, that is, the user can carry the luggage regardless of the terrain with less power. By solving the weight of the luggage through the design, it is necessary to allow the user to experience of relaxation that the original picnic gives.

1.3. Research Aim & Scope

- Research Aim

The purpose of this study is to identify picnic behavior patterns and user latent needs in various situations for people who enjoy picnics, and to a propose new concept product for picnic users that have recently increased. This can be extended to the proposal of a future transport method about short-distance personal luggage and to its product styling.

- Research Scope

The scope of this study was limited to researching, analyzing, and designing existing luggage carrying tools and equipment in order to provide convenient luggage carrying and storage according to user's picnic usage behavior analysis. Through the extracted data, it covers from 2D and 3D visualization to final test prototyping.

2

Preliminary Study

2.1 Existing Carrying Tools for Picnic

2.2 Limitations

2. Preliminary Study

The previous section covered goods that needed to each picnic activities. This leads to the issue of efficient carrying of goods in a picnic. In other words, for 'to see', 'to eat', and 'to move' activities, appropriate goods for each are needed and, by researching existing tools or products that help carry goods, possibilities of design for more efficient transport of luggage can be discovered.

2.1. Existing Carrying Tools for Picnic

2.1.1. Hand-Carry Type

- Box Type

A box is a type of container for storing things, and is usually shaped like a cube. The boxes used in picnics are type of folding box and milk box type. They are made of plastic and can hold a lot of luggage and sturdy, and the user carries the box with both hands. The biggest feature of boxes used in picnics is that they are used in a variety of uses. The box can be turned upside down and used as a chair, or as a table for putting stuff or food. However, it is heavy compared to other tools and has the disadvantage of constraint of both hands when carrying luggage.

Figure 5. Examples of Using a Picnic Box

- Basket

In a dictionary sense, a basket is a stiff container that is used for carrying or storing objects. Baskets are made from thin strips of materials such as straw, plastic, or wire woven together. It has a handle and can be easily carried by hand. Traditionally, it has a lattice shape, and in modern

times, it is sometimes made of plastic or metal. It has the advantage of being able to easily move multiple objects at once, and has the advantage of being lighter and non-breakable compared to earthenware and ceramics, so it has been widely used as a transportation tool since ancient times. In modern times, there are many forms such as shopping carts, rattan baskets, and clothes baskets, and the basic square shape makes it easy to store food, clothes, and other items. In the case of a picnic, it is used when moving with lunch boxes, fruits, and belongings, and it is also used when moving items such as fragile glass bottles because it can protect contents to some extent from external shocks.

Figure 6. Various Types of Picnic Baskets

- Trunk Type

The trunk is a combination of a box and a bag which has a handle and is made with various materials such as leather, synthetic resin, and wood. It has a handle in the shape of a box and can hold a relatively large number of objects. Dividers are placed inside to help with professional storage that fits the purpose. When it comes to picnics, there are products that are mainly made of rattan, which can hold fragile dishes or glass bottles and move tableware safely. It is used in professional use, such as for storing tools for drinking tea outdoors and for eating.

Figure 7. Examples of Storage inside Picnic Trunks

- Tote Bag Type

Tote bag is a type of handbag and refers to a bag in the form of a sack that can be carried with one hand. It is made with canvas, one of the cotton fabrics. It is a popular item even now, as it can be made a variety of designs through dyeing or printing on canvas or cotton in fashion. The sizes range from eco-bag size that you can easily carry in everyday life to big size for travel, and When users want to go out lightly, but leather bags are too heavy, or backpacks and handbags are burdensome, it can be carried lightly and comfortably. Due to this feature, tote bags which personal luggage can be easily inserted and taken out are widely used in picnic activities.

Figure 8. Examples of Tote Bag for Picnic

- Backpack Type

A backpack is a type of bag that includes rucksack, knapsack, pack and refers to a bag carried on user's back and worn on both shoulders. It is the most widely used bag in everyday life, from student bags to outdoor use. It has various storage spaces and features a relatively large amount of luggage and can be carried. In particular, outdoor backpacks are efficient for carrying heavy luggage and traveling long distances. The reason is that it can distribute the weight to the shoulders, waist, and pelvis. In addition, unlike other tools, it has the feature that both hands are free when users carry the luggage. Because of the versatility and convenience of the backpack, it can be seen that the backpack used in daily life is used for picnics as it is.

Figure 9. Several Backpacks Used for a Picnic

2.1.2. Cart Type

In a dictionary sense, a cart is a small vehicle with two wheels that is pushed or pulled with your hands, used for carrying goods. Using the wheels, the user can pull the load without lifting it by hand, so it is possible to move a large amount of luggage with relatively little force. The type of cart used in picnic activity is a folding wagon with four wheels. However, due to the character of the wheel, the terrain is limited and also the user should pay attention to adjusting the direction while pulling the weight.

Figure 10. Camping Wagon, Folding Cart and Luxury Trolley for Picnic

2.1.3. Others: Kickboard, Bicycle, Robot etc.

Personal mobility including such as kickboards or bicycles is not a product for the purpose of carrying picnic luggage originally, however they are also used in environments where luggage is carried due to the characteristics of the product having mobility. It is used by separately installing a basket or a device to put luggage on the product. Due to the characteristics of the wheels, it is possible to carry many luggage at once with little force. Recently, with the development of autonomous driving and robot technology, a design concept of a robot that transports a user's luggage is also emerging. It recognizes the user as a camera, carries the user's luggage, and

automatically follows the user with a wheel motor. Users can obtain physical freedom from the weight of a load without lifting or dragging it as in the past.

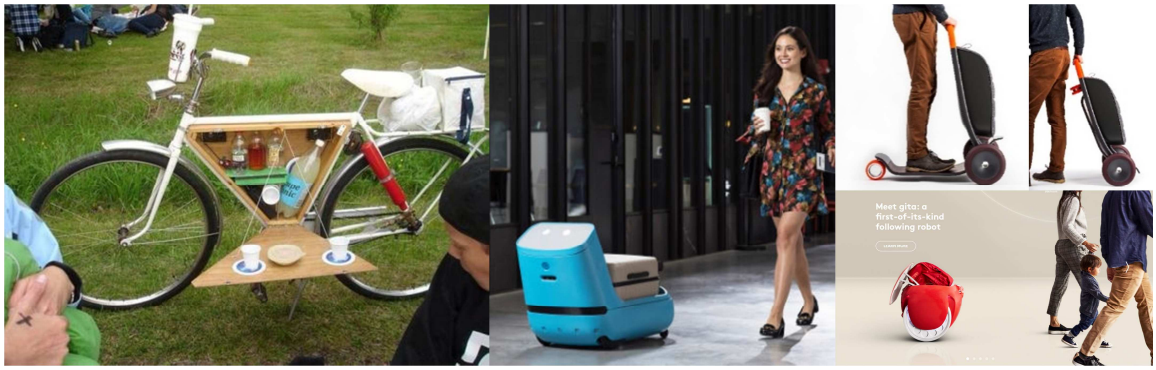

Figure 11. Design Concepts for Personal Luggage Carrying

2.2. Limitations

So far, the characteristics and advantages of hand carry type, cart type and other types have been investigated. However, from now on, the inconveniences that existing products and tools still have when carrying personal luggage are looked at and opportunities for design improvement are dealt with.

2.2.1. Heavyweight

The main limitation of the existing hand carry type is that it can hold a variety of luggage, but the user must bear and lift the weight that becomes heavy due to it. As a result, physical fatigue or injury may occur.

- Box Type: Users have to put on a heavy load and lift the weight with the strength of both arms. In addition, it does not reduce the weight of the load in terms of users and has only the characteristic of being able to carry several types of luggage at once.
- Basket & Trunk Type: Various luggage can be put in and out easily, and the handle makes it possible to carry multiple loads with one hand. However, the handle does not relieve the weight users need to lift.

- Tote Bag & Backpack Type: Since the load is carried in the form of a shoulder or back load rather than the strength of the arm, users can carry a relatively heavy weight compared to the previous box type or basket type. However, it cannot relieve the load applied to the shoulder and back, which may cause physical fatigue to the user.

Figure 12. Too Many Types of Luggage and Heavy Weight

2.2.2. Terrain Constraint

In the case of the cart type, there are constraints of usage according to the terrain due to the characteristics of using wheels. On a flat or paved road, the wheels can carry more loads with less force than the conventional hand-carry type. However, the environment in which a picnic is carried out and in the process of moving to the destination is not only a flat road, but also various environment such as ramps, mountain roads, stairs, sandy beaches, and unpaved roads. For example, if there are stairs or a gravel dirt road on the way to a picnic spot, the user has to lift a cart to move it, so more force is required than when lifting the luggage by hand without using a cart. In the case of electric bicycles, electric kickboards, and luggage-carrying robots discussed above, they also use wheels, so they still have the limitation of terrain constraints.

Figure 13. Environments Difficult to Use Wheels such as Stairs, Slope and Sand Field etc.

2.2.3. Weight of a Tool itself

In the case of electric bicycles, electric kickboards, and new concept products using mechanical and electric power, the weight of the product itself, including the battery and frame, may also be a burden to the user. If the weight of the product is heavier than the weight of the luggage, even if users can transport personal luggage without the burden of the weight, if the product is loaded or transported in a car, product weight itself may become another luggage for the user. For example, in the case of electric kickboard currently sold, the weight belonging to the light weight is 9 kg, however it is unreasonable to carry it separately.

Figure 14. Heavy Weight of Kickboard and Bicycle

2.2.4. Constraint of Both Hands

To lift or drag a load into the tool, the users should use their hand. In such a case, in the case of the hand carry type, the user should use one or both hands to lift the load. For the cart type, the users should use their hands to pull the cart and control the direction. In this case, users are restricted from other activities that use their hands, such as taking pictures while on the go, making phone calls, and other activities that can occur during a picnic, such as walking holding hands with a lover. Such restrictions of activities do not provide a convenient experience for users during picnic and may reduce the satisfaction of picnic.

3

Empirical Study

3. Empirical Study

3.1. Research Method

3.1.1. Digital Ethnography

The aim of this research method is to verify in real environments the limitations of the luggage carrying tools previously examined and to find improvements/characteristics in carrying tools that can give a new picnic experience analyzing users' behavior in picnic activities. This study conducted digital ethnography, one of the qualitative research methods, using the picnic [1]V-log video uploaded by people on YouTube. Digital ethnography is a method of ethnography among cultural anthropology methodologies, it is a method that a researcher observes based on images or video uploaded by respondents rather than observe the behavior by participating directly in the field. YouTube has recently attracted attention as a new form of data that can observe human behavior and situations in the field of digital ethnography (Blythe & Cairns, 2009). Thanks to smartphones, video diaries, and tasks like photo uploads, researchers can now look into respondents' lives without having to be physically in the field. It is fast, personal and flexible. In other words, this makes it easier for a researcher to access in-depth insights. In addition, it is possible to infer the mind of the respondents to be observed such through V-log subtitles or recorded voices. Since it is possible to secure voluntary and active "Think Aloud" data, it is used as major observation data in the recent user behavior research field (Paay, Kjeldskov, Skov, & O'Hara, 2012).

Figure 15. Digital Ethnography[2] through YouTube Video

[1] V-log: a combination of video and blog, which means leaving a record as a video on web as if writing on personal SNS. V-log uses video platforms such as YouTube and various internet streaming platforms as media, and has a characteristic that it mainly deals with everyday topics.

[2] How to Use Digital Ethnography to Understand Real Product Use [Relevant Insight]. (2021, Jan 19).

3.1.2. AEIOU Framework

Picnic V-log video uploaded on YouTube was analyzed in terms of activities, environments, interactions, objects, and users through the AEIOU framework. The AEIOU framework is a behavior observation methodology first used by Doblin in the United States in 1991 and was created with the aim of helping data and conversation analysis. AEIOU framework is a heuristic research tool that helps interpret ethnographic observations (Wasson, 2000). AEIOU consists of five elements: activity, environment, interaction, object, and user. By analyzing based on AEIOU, it is possible that structuring how the components are independently organized within the connected system and researching what insights can be produced.

- Activity: it includes all the actions an observation target does, such as special movements, action with purpose or how to use something.
- Environment: it refers to the temporal and spatial environment in which situations and actions occur.
- Interaction: interactions that can occur between all users and objects that exist in a situation.
- Objects: not only objects that directly interact with people, but also all objects that make up the environment.
- Users: includes everyone in the environment being observed.

Retrieved from https://www.relevantinsights.com/articles/digital-ethnography-to-understand-real-product-use

3.1.3. Research Flow

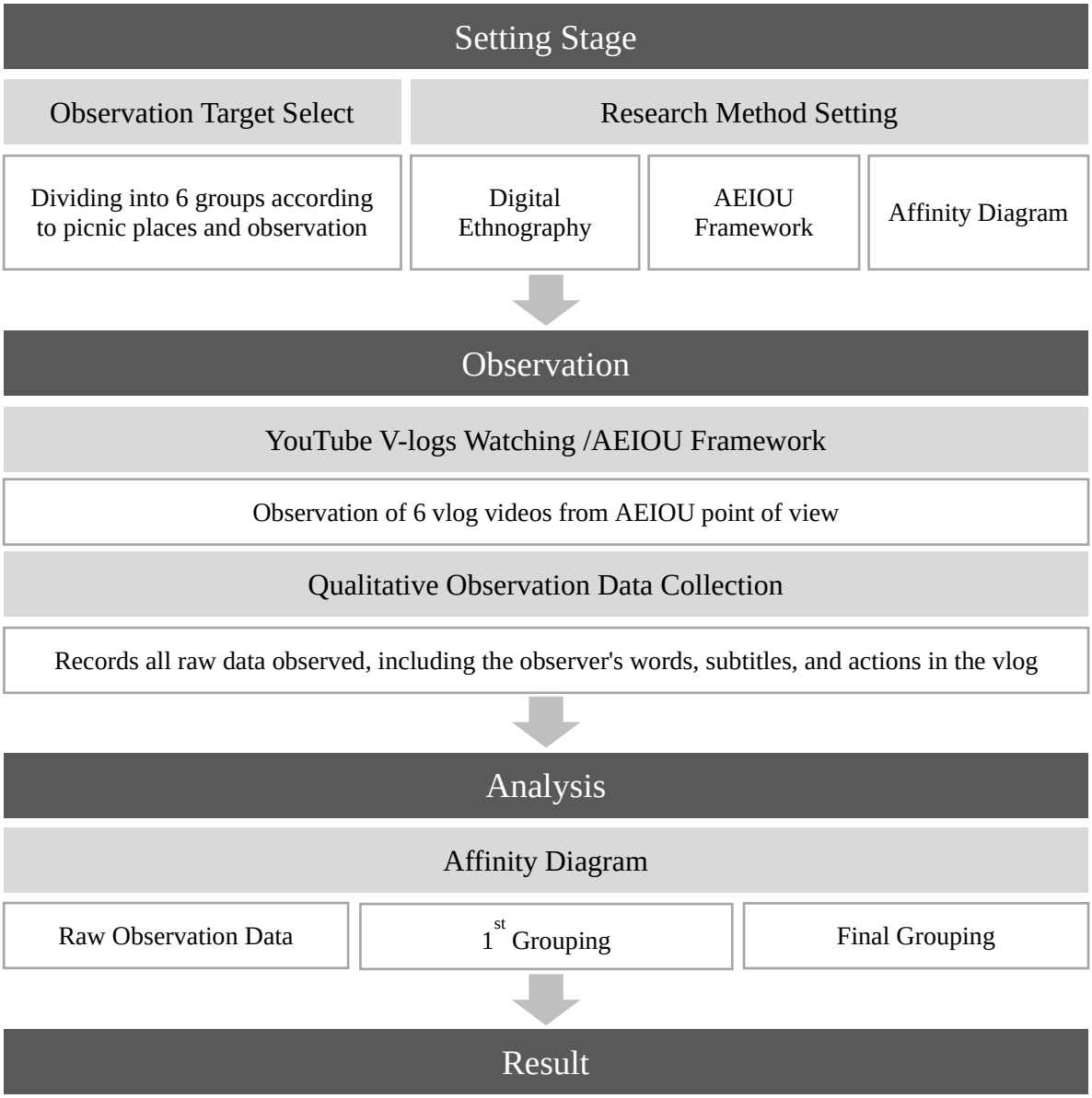

Figure 16. Schematic Diagram about Research Process

Research flow is divided into 4 stages: setting stage, observation stage, analysis and result. First, in the Setting Stage, selecting the YouTube V-log video is conducted by setting the criteria appropriate to the topic. In the observation stage, the selected YouTube V-log video is watched and the researcher observes how and with whom observation targets enjoy the picnic from the perspective of the camera. In analysis stage, the previously V-log is repeatedly played and the contents contained in the V-log are analyzed in depth based on the AEIOU framework. Raw data obtained from analysis are grouped bottom-up based on mutual relevance. In the result stage, characteristics and results of behavior in the picnic activity are derived.

3.2. User Behavior Research

3.2.1. Setting Stage

The observation V-logs were selected based on the purposeful sampling method mainly used in qualitative research (Palinkas, et al., 2015). In order to find out the user's behavior according to the place where the picnic takes place generally; parks, riversides, valleys and beach, the data was secured by searching YouTube video data based on the keywords in Table 1. After that, screening process was carried out depending on whether the behavior of the observation target was recorded in detail in Vlog.

Group	YouTube Keywords	Environment	Members of People	Observation Picture
A[3]	#Park #Picnic #V-log	Busan Citizen Park	20's Woman 1 20's Man 1	
B[4]	#Han River #Picnic #V-log	Nanji Hangang Park	20's Woman 1 20's Man 1	
C[5]	#Park #Picnic #V-log	Banpo Hangang Park	20's Woman 5	

[3] 찬찬이chanchan. (2020, May 24). VLOG #4|남자친구와 부산시민공원 피크닉 브이로그 [Video]. YouTube. Retrieved from https://www.youtube.com/watch?v=VSm9cot0Pvg

[4] 라이온다이어리_LION DIARY. (2020, Oct 14). 난지 한강 공원 브이로그 가을 한강 피크닉 [Video]. YouTube. Retrieved from https://www.youtube.com/watch?v=MwUN2URu6ks

[5] 푸우's Puwoo. (2020, Aug 12). [한강 피크닉] 날 좋은 날 가기 좋은 반포한강공원! 한강 먹방이 최고 [Video]. YouTube. Retrieved from https://www.youtube.com/watch?v=lzNwREfDfR4

D[6]	#Park #Picnic #V-log	Daegu World Cup Stadium Park	20's Woman 3	
E[7]	#Valley #Picnic #V-log	Gwanaksan Valley	20's Woman 5	
F[8]	#Beach #Picnic #V-log	Jeju Geumneung Beach	20's Woman 2	

Table 1. YouTube Vlogs Filtered by Picnic Areas

Among a total of 38 images exposed as search keywords, 6 video clips suitable for the purpose of research were selected as the final analysis target. The average length of the selected V-logs was 14.2 minutes, a total of 1 hour and 25 minutes, and a total of 19 people were observed, including 2 teams of couples and 6 teams of friends.

3.2.2. Observation

Data were collected by repeatedly watching all the contents in selected vlogs, focusing on the user's activity aspects, environmental characteristics, interaction issues, all objects, and people in the video respectively. Based on the subtitles in the video and the recorded voice of the observation object, it was possible to know the observation target's thoughts, and it was also recorded as raw data.

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[6] 유자. (2016, Nov 6). [유자] 브이로그 | 솔유정의 가을 피크닉 | 대구스타디움에서 피크닉을! [Video]. YouTube. Retrieved from https://www.youtube.com/watch?v=Tg88BvP5wvM

[7] STHELOG스더기. (2018, Aug 30). 이쁜이 불사조와 함께하는 관악산 계곡 브이로그 [Video]. YouTube. Retrieved from https://www.youtube.com/watch?v=Ofv_qLCk57s

[8] 안구정화TV, Your Korean Friend. (2019, Apr 6). 봄 제주도 바닷가에서 피크닉하기 | 일상 힐링 브이로그 | 앙구 브이로그 [Video]. YouTube. Retrieved from https://www.youtube.com/watch?v=fgSfBNErYqA

3.2.3. Affinity Diagram

Through the affinity diagram, large keywords that fit the categories of Activity, Environment, Interaction, Object, and User were extracted.

Final Grouping	1st Grouping	Observation Contents	Group
Difficulty of carrying due to many kinds of luggage and weight	Limited number and weight of luggage that can be carried by hands	Carrying a basket, ice box, and eco-bag with both hands to a picnic area	A
		The sea water comes in during a picnic, so lifting a table and moving back.	C
		Each person carries their luggage, leaves the beach and moves to a car.	C
		Being bumped a shin into the chair while carrying a chair	C
		On behalf of the older sister who is filming, she holds her luggage under her armpit and lifts it instead.	C
	Inconvenience of carrying luggage and camera photographing simultaneously	Carrying luggage in one hand and Taking videos and photos while moving with a camera or selfie stick.	B
		A situation where observation targets should lift luggage while taking a video of the beach with a camera	C
		Spilled coffee and asking a friend to lift luggage for a moment	B
Lifting or Dragging Luggage depending on Terrain and Weight	Using tools to carry luggage, but there is a hassle	Put full luggage on the kickboard and move to a parking lot	A
		Loads all luggage on a cart and moves to the Han River while dragging a cart alternatively	F
		Situation of transporting luggage of multiple person in one cart	F
		Dragging a cart alternately with each other doing rock, scissors, paper	F
	Environment difficult to carry luggage	Wide sandy beach environment	C
		Holds a cart with hands when it goes over the jaw of the sidewalk to prevent luggage from falling	F
		World Cup park coming out after passing a	B

		long and gentle slope	
		Valley environment with dirt road and rock	D
		There is a stone bridge to move to the other side	D
		An entrance of valley that comes out after 10 minutes of climbing the paved mountain path	D
Navigating and luggage carrying by a suitable picnic spot	Finding a picnic spot to unpack luggage	Wandering around looking for a shaded place in a civil park	A
		Girlfriend goes to a picnic spot first by the kickboard	A
		People carry their each luggage and moves in search of a good place	D
		Finding a good spot walking on the sandy beach	C
		Moving to the upper reaches of the valley finding a good spot	D
		Looking for a place to sit avoiding crowded places	F
	Selecting a quiet and scenic place	Busan Citizen Park with lawns and trees along walking trail	A
		A quiet lawn where people don't get crowded	B
		Environment with shades and large lawns good for playing Frisbee	E
		A panoramic view of the Han River occurring with a short walk along the Han River walking trail	E
Supporting for photo and video shooting of various views	Photographing to record a picnic	A boyfriend takes a picture to be posted on Instagram instead	A
		Recording picnic from time to time with a film camera	A
		Lie down and take a selfie while relaxing	B
		Use a camera to take pictures of picnic food, backgrounds, and friends from time to time	B
		Install tripods and cameras for video and photo taking	D
		Taking pictures of friends playing in the water	D
		Friends pose for fun and take set-up shots	D

		Taking a selfie while watching the sunset over the Han River on the way home	E
		Put food on the table and take pictures with friends, and eat	F
		Take a video of food close-up	F
		Looking at the camera and taking a funny pose	F
	Inconvenience of taking pictures	Using legs instead of a tripod to find a good selfie angle and taking pictures with friends.	B
		Taking a group photo with a selfie stick	D
		Trying to take a group shot by extending a selfie stick as much as possible while lying down	B
		Posing while taking group selfies by extending a selfie sticks as much as possible	F
Providing enjoyment through outdoor activities	Diversion through outdoor recreational activities	Massaging a boyfriend's face	A
		Playing soap bubbles with a toy brought	A
		Playing badminton	B
		Each person enjoys 'Cart Rider' game with a smartphone	E
		Come out to the lawn and play Frisbee	E
		Take a light walk along the Han River	E
	Listening to music	Turning on the Bluetooth speaker and singing along	A
		Pairing a Bluetooth speaker with a smartphone	A
	Eating meals	Eat homemade burgers and foods that have been packaged	B
		Using thermos and coffee brewing tools to drink coffee	C
		Eat a lunch box brought	A
		Eating snack and beverage	C
		Eat fruits and ramen brought	E

Table 2. Affinity Diagram of Picnic Vlog Observation

3.2.4. Result

As a result of the analysis of picnic behavior, there were many following behavior patterns.

- Difficulty of carrying due to many kinds of luggage and weight

Figure 17. People Carrying their Personal Luggage to the Picnic Spot

As a result of observing YouTube vlogs, observation targets had a difficulty in moving luggage comfortably due to various types of luggage and weight. Specifically, limitations were observed in the number and weight of luggage that could be lifted with both hands. In addition, discomfort was mainly observed in the process of transporting luggage while filming with the camera simultaneously.

- Lifting or Dragging Luggage depending on Terrain and Weight

Figure 18. Types of Carrying depending on Terrain and Weight of Luggage

People dragged or lifted loads according to the terrain and weight. Although conventional carrying tools were used to transport luggage, limitations of the cart were observed in terrain such as the sill of the sidewalk and stairs, and even if the cart was dragged on a flat pavement, observation targets felt the weight of the load was heavy. Problems about hand carrying luggage while moving the beach, ramps, and stony valleys at the same time were also found.

- Navigating and Luggage Carrying by a Suitable Picnic Spot

Figure 19. Finding Suitable Picnic Spot

As a result of observing the YouTube picnic vlog, a common behavior of people was to find a suitable picnic spot to unpack luggage. While carrying with personal luggage, the behavior of finding a quiet, shady, and good-view spot was observed. Through this, it is possible to derive a need to guide people to the best picnic spot fast in order to reduce the movement of carrying luggage.

- Supporting for photo and video shooting of various views

Figure 20. Video Recording and Photographing

The behavior seen in most picnic vlogs is that people enjoy taking selfies and videos to document their picnic experiences. However, inconveniences of conventional photographing were observed, such as handling camera equipment while carrying luggage, or finding an appropriate shooting angle moving a tripod or selfie stick here and there.

- Providing Enjoyment through Outdoor Activities

Figure 21. Playing Badminton and Frisbee

Through vlog observation, observation targets enjoyed recreational activities such as water play, badminton, and frisbee at the picnic area. In addition, various behaviors for relaxation such as eating food they brought and listening to music were observed. Through this, a big category about pursuit of pleasure through a new kind of outdoor recreational activity in picnic was derived.

3.3. Design Insight

3.3.1. Various uses of a Drone

Drone refers to unmanned aerial vehicle, which is an aircraft that does not ride on humans and is controlled by radio waves. There are many types of drones, but they can be largely classified according to the type of a wing (Yoo, 2019). There are fixed-wing with wings and rotary-wing with rotating [9]rotors. Fixed-wing has a relatively long flight time because it consumes less fuel than rotary-wing, but it is difficult to use in urban areas or mountain terrain because it requires a certain distance for take-off. Since a rotary-wing is capable of vertical take-off and landing by the rotation of the rotor, it is relatively less restricted by the location, and low-altitude flight or hovering flight at a specific location is possible. However, it has a characteristic that flight time is shorter than fixed-wing (Korea Land and Geospatial Informatix Corporation, 2015). A drone, which has been developed and operated for military use in the past, is attracting attention as one of the cutting-edge technologies of the 21st century along with the development of IT technology. Today, a drone is used not only in leisure, but also in various private sector and industrial field

9 Rotor: a part that rotate in rotating machinery such as generators, electric motors, turbines, and waterwheels.

such as observation, agriculture, security, delivery, photography, and disaster relief, and its areas are also expanding (Kim H. , 2014). Among the use of a drone previously, in the private sector, a drone is being used most actively in logistics such as parcel delivery. Representatively, Amazon is developing a delivery service that allows customers to receive items weighing less than 2.26kg in 30 minutes through a 'Prime Air' drone.

Drones are being developed in a variety of sizes and performance depending on the purpose of use. In addition to the military use of large aircraft, micro drones are being actively developed. Also, there are many drones developed and commercialized as personal hobbies.

Drone Type	Pros	Cons	Typical Uses
Multi-Rotor	-Accessibility -Ease of Use -Hover Flight -Camera Control	-Short Flight Times -Small Payload Capacity	-Aerial Photography and Inspection
Single-Rotor	-Hover Flight -Long Endurance -Heavier Payload	-More Dangerous -Harder to Fly, Training Needed -Expensive	-Aerial LiDAR Scanning
Fixed-Wing	-Long Endurance -Large Area Coverage -Fast Flight Speed	-Launch Needs a lot of space -No VTOL -Harder to Fly, Training Needed -Expensive	-Aerial Mapping -Pipeline and Power Line Inspection

Table 3. Different Types of Drones and their Features

3.3.2. Overcoming Terrain Constraints

Features of rotorcraft drones include rapid accessibility, accuracy, and economics. (Geospatial World, 2020). In addition, there are several convenient and efficient advantages when using a drone compared to the ground transportation method. In addition, according to the Korean Maritime and Fisheries utilization plan, the future prospect of drone development in the future is being developed in the direction of long-term flight and increased loading weight. In view of this trend, if you move the load in the air, we will try to overcome the limitations according to the topography and meet the needs that emerged from behavioral observation.

3.3.3. Aerial Searching

One of the biggest advantages of drones is that they can quickly search large areas that are difficult for humans to access through the drone's camera. Due to these characteristics, drones are most actively used in fields such as life search for rescue, crime prevention, and safety diagnosis of high-rise structures. For example, if a drone dispatched to the scene transmits the size and spread of the fire to the control center in real time while rescuers are preparing to be dispatched, the rescue team arriving at the scene can effectively extinguish the fire and operate rescue activities based on transmitted information. Even in places where it is difficult for humans to search individually, such as in the mountains or the sea, it is possible to monitor forest fires, extinguish fires, and search for lives. Drones can search for missing people in the open sea, and drop life-saving equipment to the accident scene when it finds a survivor.

3.3.4. Aerial Shot & Photographing

One of the fields in which drones are widely used is in the field of aerial photography. Being able to go up in the air and look at the world from a completely different perspective than before is a big attraction that only drone video has. Aerial video using drones extends human vision beyond the simplification of flight procedures and reduction of video shooting cost (Lee M. , 2015). By attaching a camera to a drone, anyone can easily operate it and take pictures from a nice angle at a low price compared with conventional helicopter photographing. Also, unlike helicopters, drones can take close-up shots and make relatively little noise. For this reason, many photographers and broadcasting stations are shooting aerial video using drones in the process of film production. with the release of the personal mini selfie drones, it is possible to take vlogs and selfies from various angles without a selfie stick, away from taking pictures only within the length of the selfie stick.

4

Design Development

4.1 Concept Direction

4.2 Engineering Consideration

4.3 Design Styling

4.4 Modeling & Prototyping

4.5 Proposal of Usage in Picnic

4. Design Development

4.1. Concept Direction

The main functions of the design concept are determined by combining the three results from the previous picnic behavior analysis results and the advantages of the drone.

User Behavior Result		
Terrain Constraints	Finding a Picnic Spot	Photographing
↓		
Solution Using a Drone		
Efficient Luggage Carrying on Various Terrain	Quick Accessibility through Aerial Inspection	Aerial Photography

Table 4. Diagram of Setting Concept Direction

4.1.1. Luggage Carrying by a Drone

Figure 22. Applying a Drone to Carrying Luggage

The main concept of the product is to carry personal picnic loads through a drone. In the existing hand-carry type and cart type carrying tools using wheels, there were issues about the heavy

weight of loads, terrain constraints, and two hands restrictions. To solve this, by using a drone to carry the luggage to the picnic destination in the air, people can free themselves from the burden of the weight of the luggage and constraints of the terrain such as stairs or ramps.

4.1.2. Finding a Picnic Spot

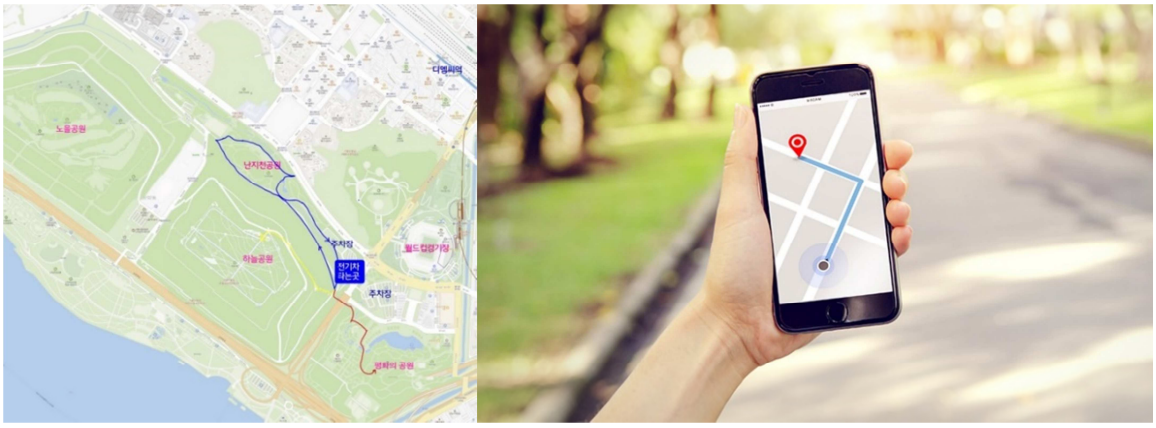

Figure 23. Navigating Picnic Spot

In the case of a picnic situation, it is inconvenient for people to carry their personal luggage and move around to look for a place with a good view, quiet and shade one by one. In this regard, if people can quickly search for a picnic spot through a drone and transport their personal luggage in advance, it can relieve the inconvenience of having to move around here and there with luggage on the way to the picnic spot.

4.1.3. Photographing People and Landscape

As a result of the previous behavioral observation, people showed behavioral characteristics to record their picnic experiences through selfies or group photos. Meanwhile, there was an inconvenience in taking pictures using a selfie stick and a tripod. First, people could only shoot within the limited length of the selfie stick. Second, there was a problem in taking photos and videos while holding a personal luggage and a selfie stick at the same time. Instead of selfie sticks and tripods, a drone tracks users and takes aerial shots, allowing users to record a picnic from any angle without the need for devices such as selfie sticks and tripods.

4.2. Engineering Consideration

In order for the concept to work, the engineering criteria that must be satisfied are investigated and reflected in the design. The minimum thrust to lift a certain weight is secured, the propeller size is adjusted accordingly, and the sense of proportionality with the main body is adjusted. Battery capacity is an important factor related to flight time. To do this, set the maximum operating time.

4.2.1. Target Take-off Weight & Flying Time

First, set how many kg the drone can cover the weight of the luggage. Based on the weight of the luggage you usually carry, we set the weight you can carry during picnics or camping. Based on the data of AEIOU Object, the target take-off weight is set. The total target weight of 5kg and the flight time is set to 50 minutes. For picnics and outdoor activities, it was set to move by car and move the luggage to the destination by drone, and the time was set by drone for 25 minutes round trip and 50 minutes. Longer flight time on a single charge is good, but as the flight time increases, the weight of the battery increases. In other words, if the user does not carry their luggage with a drone, the weight they have to bear increases. The portability concept required a balance between the weight of the battery and the operating time. Here, the maximum weight of the unloaded product is set to 4.33kg by setting the maximum travel time without rest to 50 minutes for the user to pick up and charge.

4.2.2. Propeller & Battery

Find out the thrust according to the motor and propeller combination. The thrust must be greater than the weight of the product in order to be loaded and unloaded. In the case of thrust, based on the test table (Appendices) according to the combination of T-motor's motor and propeller, it was obtained on the premise that the company's parts were used. The maximum weight of the drone is set as the constant weight of personal luggage (5kg) + weight of parts + battery weight. The most important thing about the battery is that it is lightweight and has a long flight time. To this end, an 18650 lithium ion battery was applied. It has higher energy density and lighter weight than other nickel cadmium and nickel hydride secondary batteries. Also, considering that it is a concept product in the near future, the limit energy density of the 18650 lithium-ion battery, 350Wh/kg, was applied (Ding, Cano, Yu, Lu, & Chen, 2019).

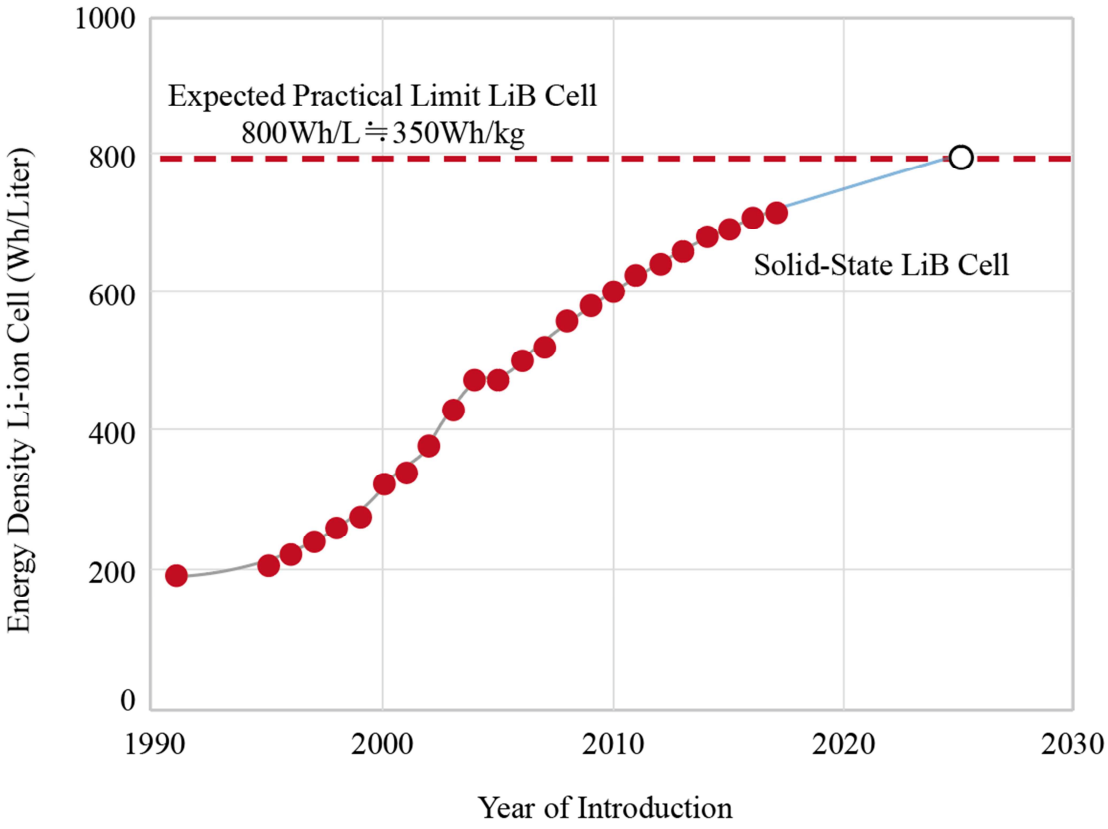

Table 5. Li-ion Battery Energy Density Development and Expectation

Li-ion batteries can be connected in series and in parallel, making it easy to apply to products. An ideal lithium-ion battery with a nominal voltage of 3.6V, a nominal capacity of 4,655mAh and a cell weight of 50g was calculated and calculated. It lifts 5kg of personal luggage for 50 minutes, and the combination that can make the weight of the product lighter was to apply a 16-inch propeller to the MN4014. In the light gray text area Table 7, the Thrust is less than the total max weight, so there is not enough force to lift the load. The black text area is a valid value with Thrust greater than the total max weight.

Specification	Current Li-ion Battery (INR18650)		Ideal Li-ion Battery
Energy Density	263Wh/kg	→	**350Wh/kg**
Nominal Capacity	3,500mAh	→	**4,655mAh**
Cell Weight	50g	→	**50g**

Table 6. Ideal Li-ion Battery Specifications

Motor type	Propeller type (diameter * Pitch)	Voltage(V)	Current(A)	Battery(kg)	Thrust(kg)	Total weight including max luggage(kg)	**Total weight of product itself(kg)**
U5 KV400	P15*5	22.2	68.8	3.69	9.92	9.90	4.90
	P16*5.4	22.2	60.0	3.22	9.54	9.45	4.45
U7 V2.0 KV420	P15*5	22.2	98.8	5.31	12.12	11.91	6.91
	P16*5.4	22.2	96.8	5.19	12.20	11.81	6.81
MN3515 KV400	P16*5.4	22.2	59.8	3.21	9.46	9.42	4.42
MN3520 KV400	P15*5	22.2	81.2	4.36	10.8	10.72	5.72
	P16*5.4	22.2	77.6	4.16	10.72	10.54	5.54
MN4014 KV330	P16*5.4	22.2	58.8	3.15	9.56	9.35	4.35
MN4014 KV400	**P16*5.4**	22.2	58.4	3.13	**9.52**	**9.33**	**4.33**
MN501S KV240	P15*5	48.5	73.24	8.59	15.82	15.57	10.57

Table 7. Applicable Motor and Propeller Combinations

When lifting the target 5kg of load for 50 minutes, the lighter the battery weight, the lighter the overall weight, which is more efficient. Also, for compact bags, the smaller the propeller diameter, the less space it occupies, the more efficient it is for storage. In the case of Thrust, the larger the load is, the better. In other words, efficiency is inversely proportional to battery weight and propeller size, and is proportional to thrust. By expressing this as an equation, the efficiency corresponding to each combination is as follows.

Efficiency $\propto$ Thrust

$$\propto \frac{1}{Battery\ weight}, \frac{1}{Propeller\ diameter}$$

$$\text{Efficiency} = C \times \frac{Thrust}{Propeller\ diameter \times Battery\ weight}$$ (C is arbitrary constant)

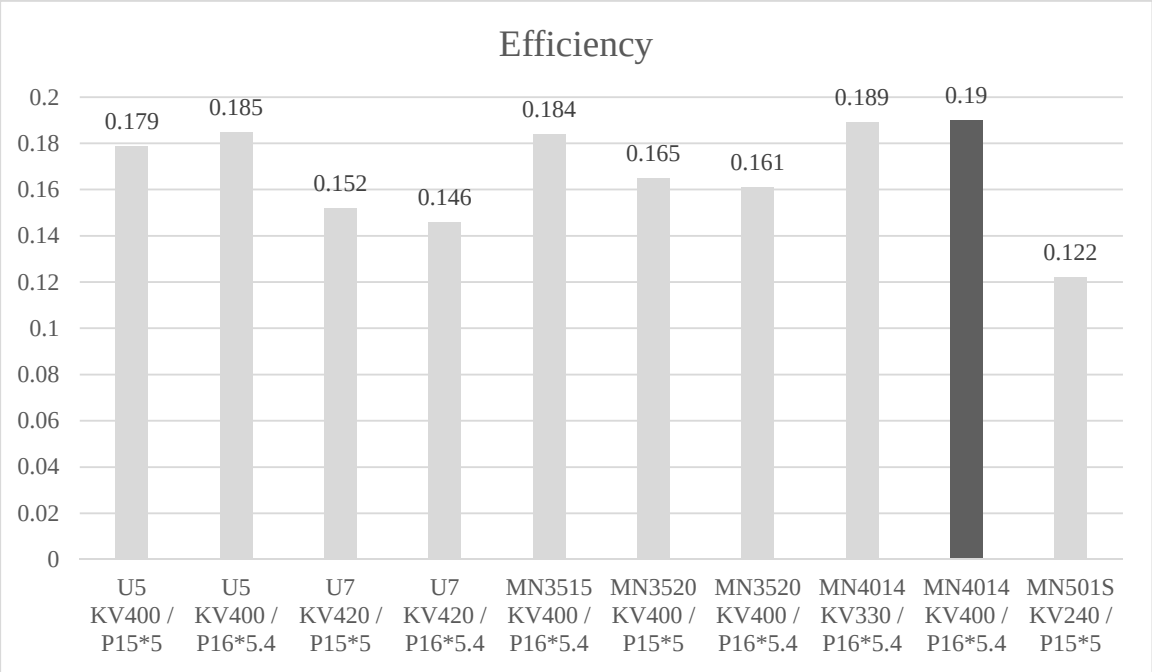

Table 8. Efficiency according to Motor Propeller Combinations

4.2.3. Dimension

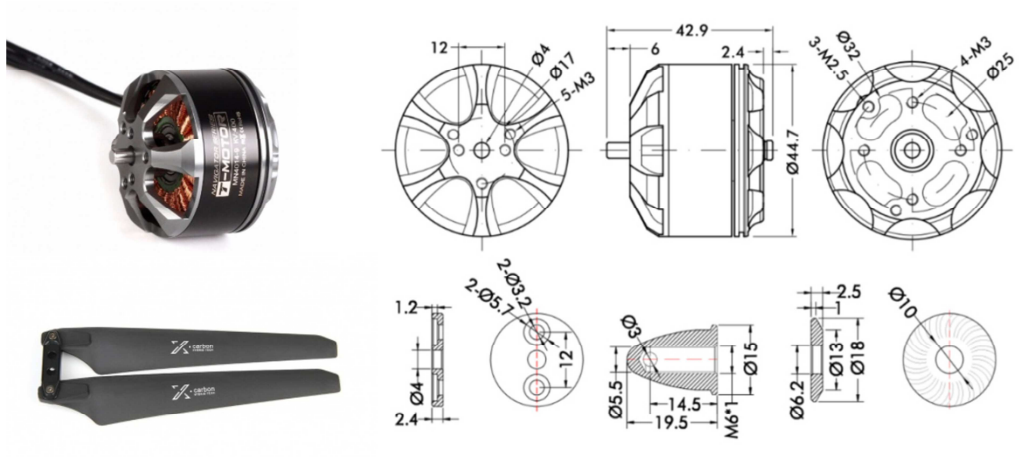

Figure 24. Selected Motor Dimension and 16-inch Propeller

The motor and propeller combination satisfying the target thrust is to apply MN4014 KV400 and 16-inch propeller. Considering the size of the motor and propeller, the width and length of the entire product were set to 35.6 cm, and the height was set to 60.5 cm.

4.3. Design Styling

4.3.1. Iconic & Light & Vivid

As a starting point for design styling, three keywords were used as styling themes to project the image of a light and bright picnic, while inheriting the form of existing picnic baskets.

Figure 25. Styling Mood Board

- Iconic: The shape of the existing drone mainly has a body in the middle and 4 propellers are connected to the body. Also, in the case of the existing drones, many engineering factors were reflected in the design considering air resistance, weight, and space efficiency from the viewpoint of the flying vehicle. As a result, when looking at the shape of the drone, it is characterized by a techy and functional design. The concept design in this study, usability in picnic situations should be considered in addition to functionality. In other words, Reflecting the biggest feature of this concept, which is storing and carrying luggage, the usability of the product in a picnic situation should be considered in form styling. In addition, there was a need to find the adequate form that can enable aerial searching for picnic spot and camera shooting functions at the same time as carrying luggage. Overall, it is a drone with the silhouette of an existing handbag, and the organic appearance and functional form of the handle will be reflected to the exterior styling.

- Light: In the case of this concept, it is a drone that carry personal luggage, and it should be styled so that the user can visually experience a light image when using the drone. The image that the heavy feeling given by luggage itself can be lightly transported by the drone should be reflected in the form. In addition, in terms of physical weight, it shouldn't be heavy when a user uses it. To this end, it is necessary to find a structure that is light and can produce optimal space efficiency by reflecting the specifications of the motor and propeller above.

- Vivid: In terms of color other than the shape, it is necessary to use a high-saturation and bright color suitable for a picnic image on a sunny day. The use of bright color can add a pleasant user experience not only to personal luggage carrying but also to additional activities, such as aerial photographing and picnic spot searching, using a drone.

4.3.2. Idea Sketch

- Thumbnail Sketch

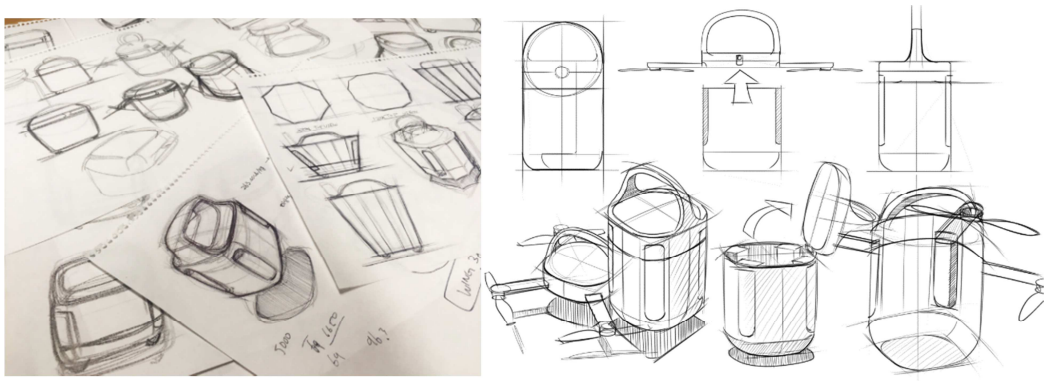

Figure 26. Thumbnail and Rough Sketches

Through the first thumbnail sketch, it was decided as a cubic with round corners among various drone shapes. After that, the optimal aspect ratio among several cubic with rounded corners was determined. According to a set ratio, the drone is placed at the top of the product and a container is designed to store luggage at the bottom. In the case of the propellers, a vertical folding way was applied for space efficiency.

- Detail Sketch

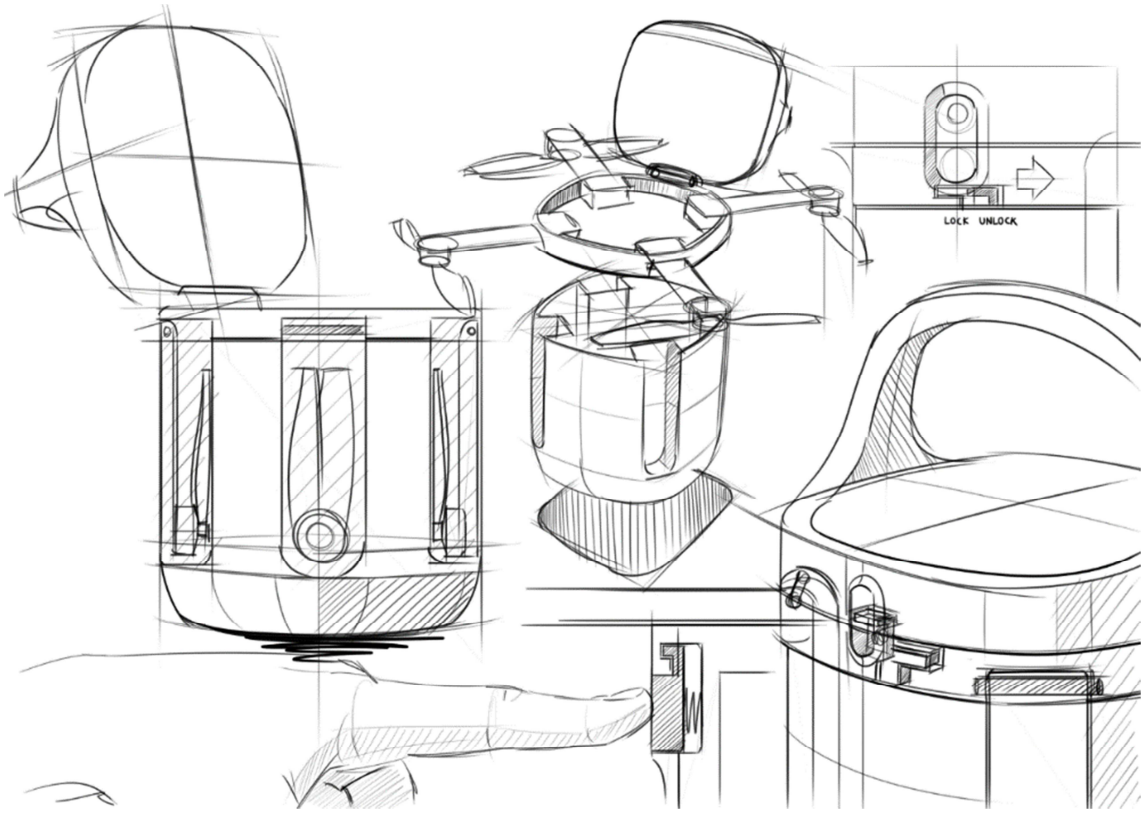

Figure 27. Detail Sketch about Inner Structure

In the second sketch, detailed sketches for each part were carried out. Considering the propeller folding way, the internal structure is embodied so that sufficient space is secured when the propellers and motor are folded. Also, hinges and hooks were respectively applied as fixing ways for lids, upper drone and bottom container.

4.4. Modeling & Prototyping

4.4.1. 3D Modeling

- Overall Size

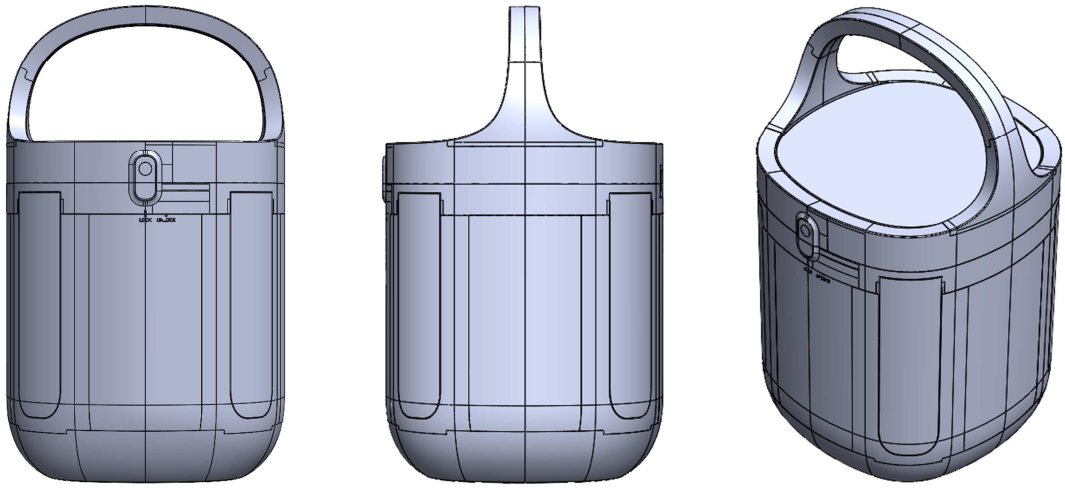

Figure 28. Front, Side and Perspective View

It started with a cubic measuring 35.6 cm in width and 60.5 cm in height and developed into a basket-like shape with a handle. As a whole, the shape of a rectangle with rounded corners, not sharp corners, was applied.

- Folding Wing

In consideration of inner space efficiency of the drone, a folding type 16-inch (40.64 cm) diameter propeller was applied. 4 wings and arms are designed in such a way that they are folded into corners of the container when not in use and unfolded when carrying luggage. To this end, it was necessary to secure sufficient space by calculating the size of the internal propeller and motor, and internal design was carried out to prevent interference between the folding hinge part and body.

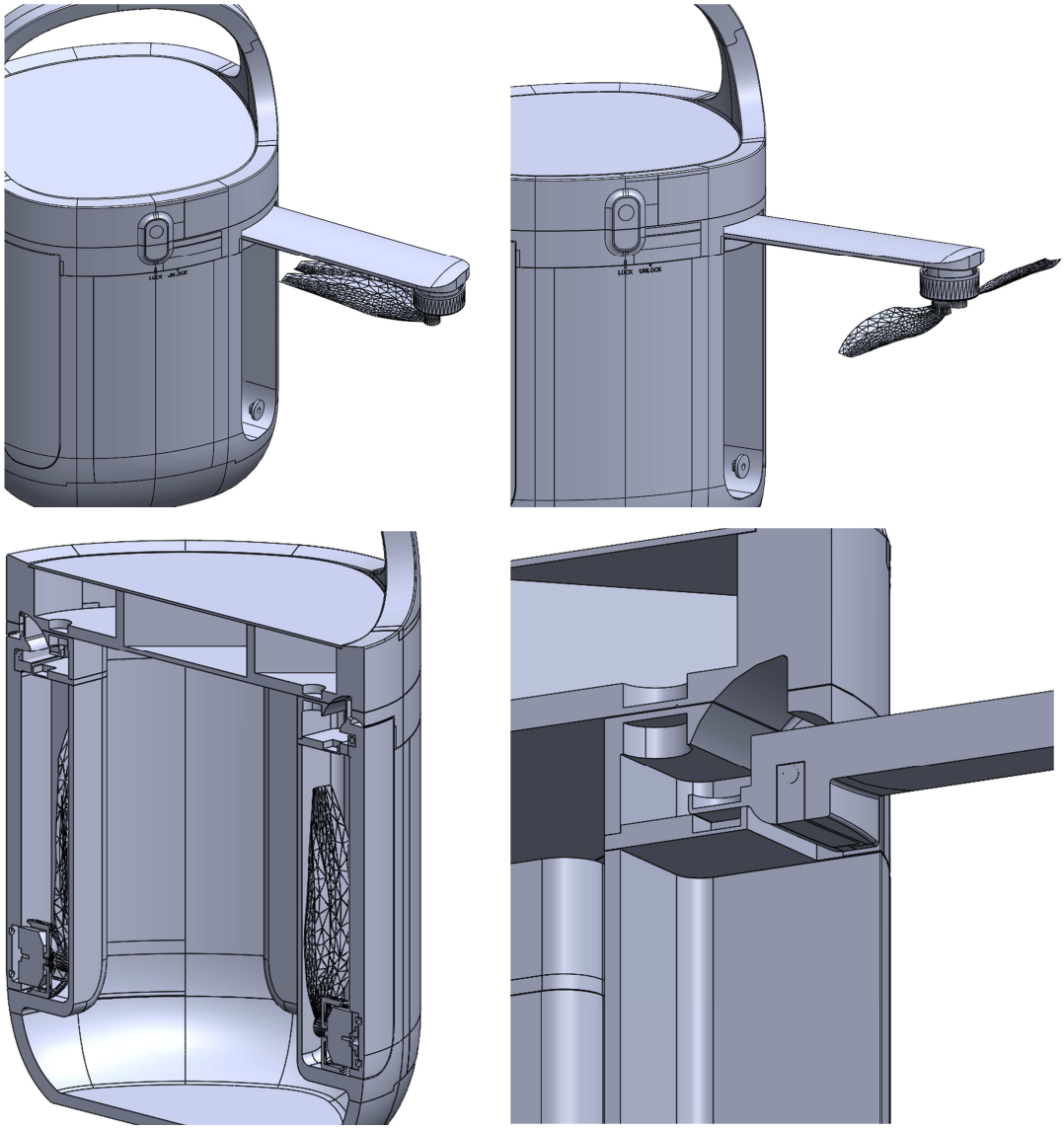

Figure 29. Folding Propeller and Arm Structure

- Battery Integrated Hinged Lid

Li-ion battery is located on the top of the lid. Users should be able to quickly and easily put into and take out personal luggage while on a picnic. So that the structure of the drone should not disturb putting into and taking out luggage, battery integrated hinged lid was located on the top of the drone and users can open and close it. In addition, it is designed to fix and open the lid using a push-open button. Users can put into and take out personal luggage by pressing a button and leaning back the battery integrated lid.

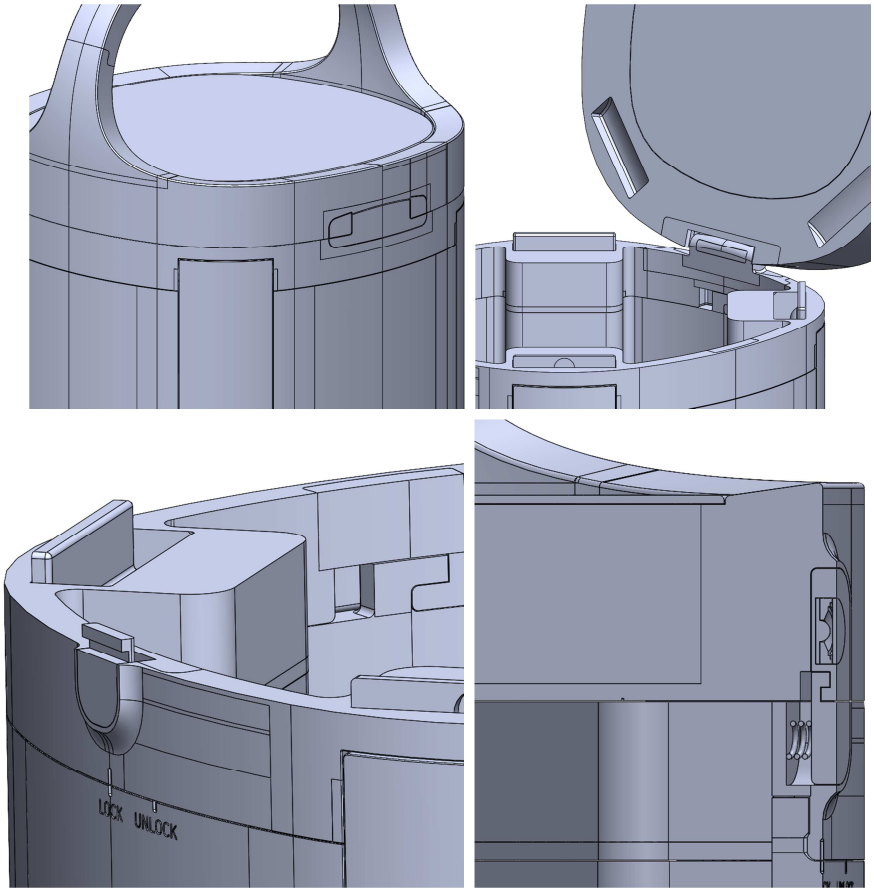

Figure 30. Structure Design of a Lid Hinge

- Drone Separation & Combination

For aerial photography and picnic spot searching, users can separate the top drone part and the bottom container apart. Users can separate and fix the drone and the container by unfolding 4 wings of the drone and turning the top part clockwise slightly.

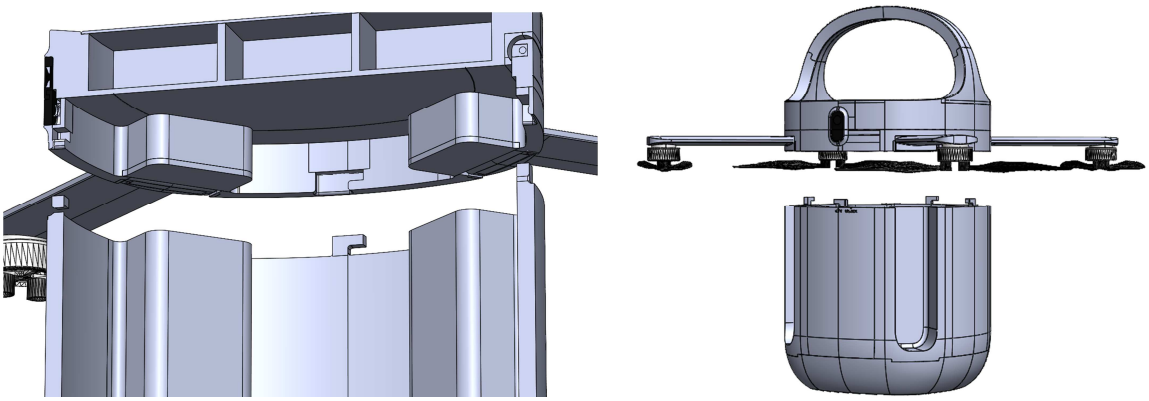

Figure 31. Joint between Drone and Container

4.4.2. Rendering

- CMF

Figure 32. Color and Semi-Clear Surface

The main color of the drone is Pantone 172C. It was intended to add a bright and cheerful experience of picnics through vivid color. In addition, lightweight plastic was used as the material of the product. For maximum flight efficiency, lightweight but rigid material were considered, as it was needed to keep the light weight of the product while still protecting the internal luggage. For finishing, a smooth semi-gloss surface was applied. It was intended to deliver the simple and clean appearance of the product through the semi-gloss finish.

- Images

Figure 33. Front, Side and Top View

The overall shape of the drone is that of a basket with a round handle. The handle part is smoothly connected to the container, and the container is a hexahedron with round curvature as a whole. A visual point was given by contrasting the camera at the top and the container.

Figure 34. Folding Arms and Propellers

A neat curved surface is realized because 4 arms are folded and unfolded vertically. The propellers are also a folding way, occupying a minimum space that is 16-inch when unfolded and 8-inch when folded, and can be compactly inserted into the container.

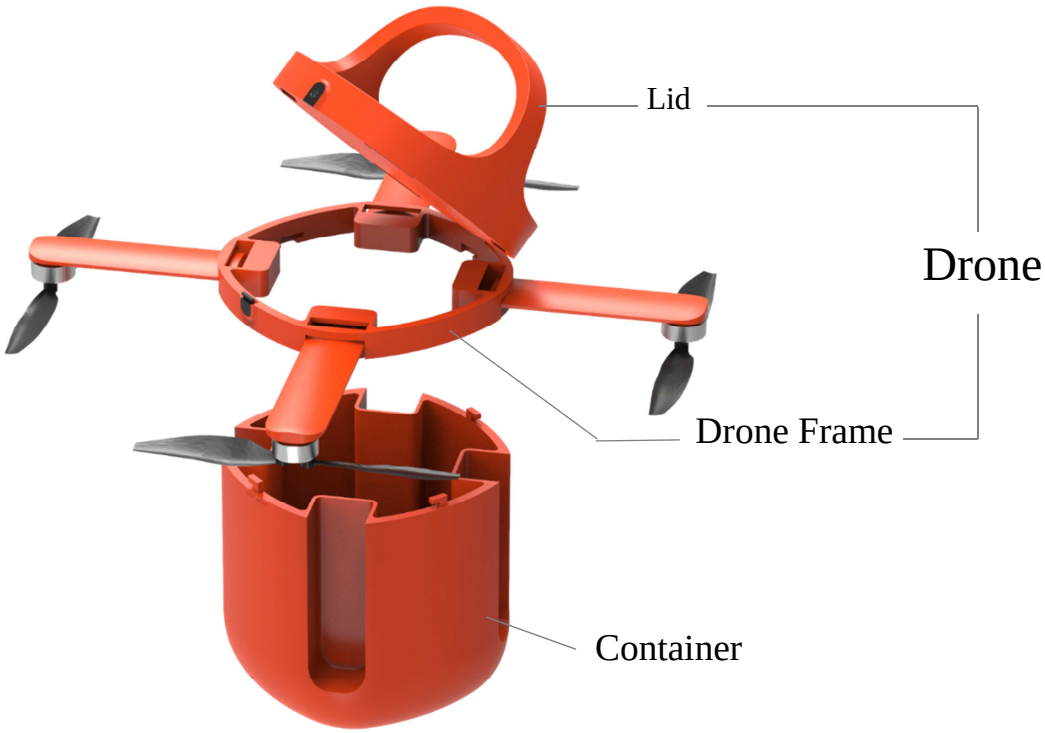

Figure 35. Components of the Picnic Drone

The camera and the open button form a rounded corner rectangle to give unity. The camera is used for picnic spot searching and aerial photography. The open button is used to separate the drone and lid to put things in.

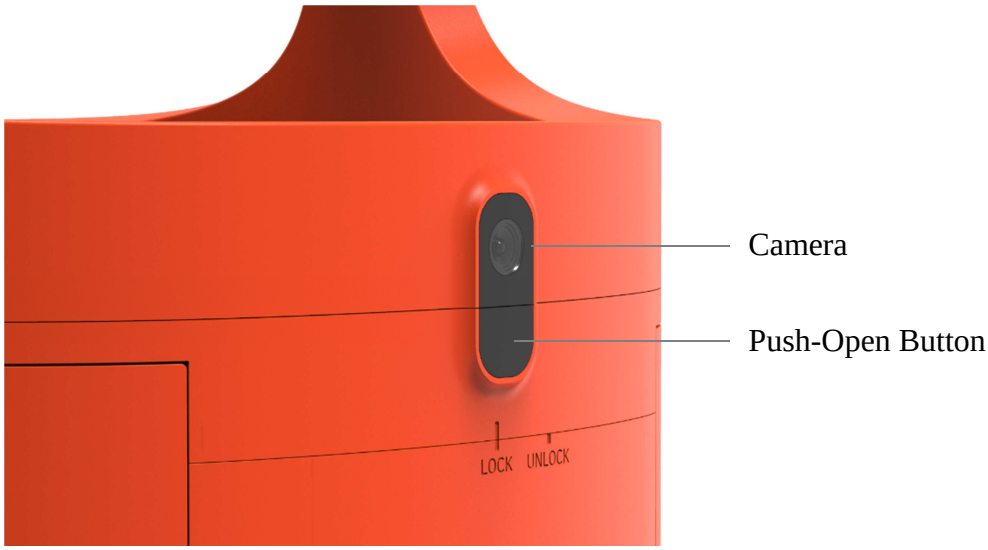

Figure 36. Drone Camera and Lid Button

4.4.3. Prototyping

Figure 37. Prototyping (1:1 Scale)

The prototype was manufactured as a 1:1 scale model (35cm x 35cm x 60cm) reflecting the size of the actual 16-inch propeller and MN4014 motor. Working lid hinge, folding propeller and folding wing arm hinge and the drone-container fixation were implemented.

4.5. Proposal of Usage in Picnic

- Luggage Carrying

Figure 38. User Scenario of Luggage Carrying

1. User puts luggage in the drone

2. User unfolds 4 arms and propellers.

3. The user makes the drone take off and sets the flight mode through a smartphone app.

4. The drone tracks and follows the user at an adequate height and speed.

The most basic usage of the drone concept is to carry the user's luggage regardless of terrain. Through this, the user can experience a joyful picnic without the physical burden of the weight of the luggage.

- Searching Picnic Spot

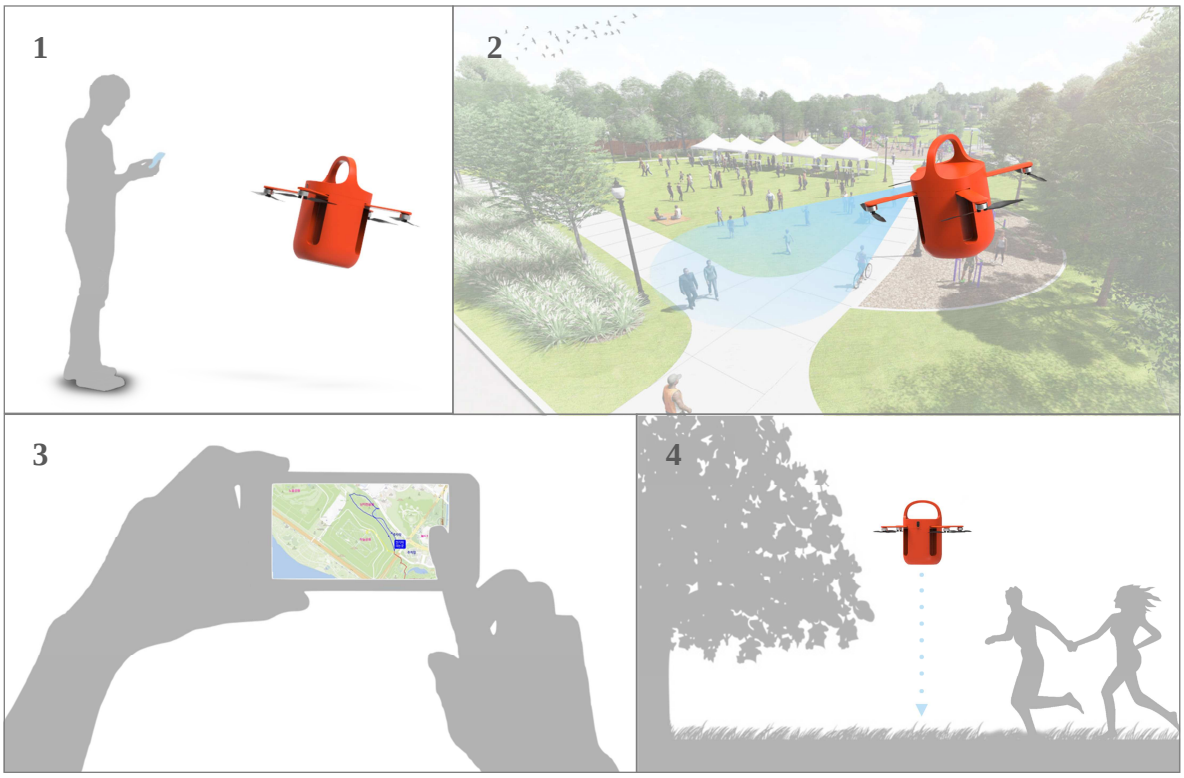

Figure 39. User Scenario of Searching Picnic Spot

1. The user who arrives at the park takes off the drone to find a good picnic spot.

2. The drone quickly searches various spots with its built-in camera and transmits the video to the user's smartphone in real time. The user watches the smartphone video and selects a favorite picnic spot.

3. The location of the drone is displayed on the smartphone, and the user moves to the location in the shortest distance while looking at the map.

4. The user discovers the drone hovering at the location and arrives at the picnic spot.

One of the additional features of the drone is that it can help users choose their preferred picnic spot. Because the drone can quickly search large picnic areas, a user doesn't have to carry luggage here and there to find the picnic spot he/she wants.

- Aerial Photographing & Selfie

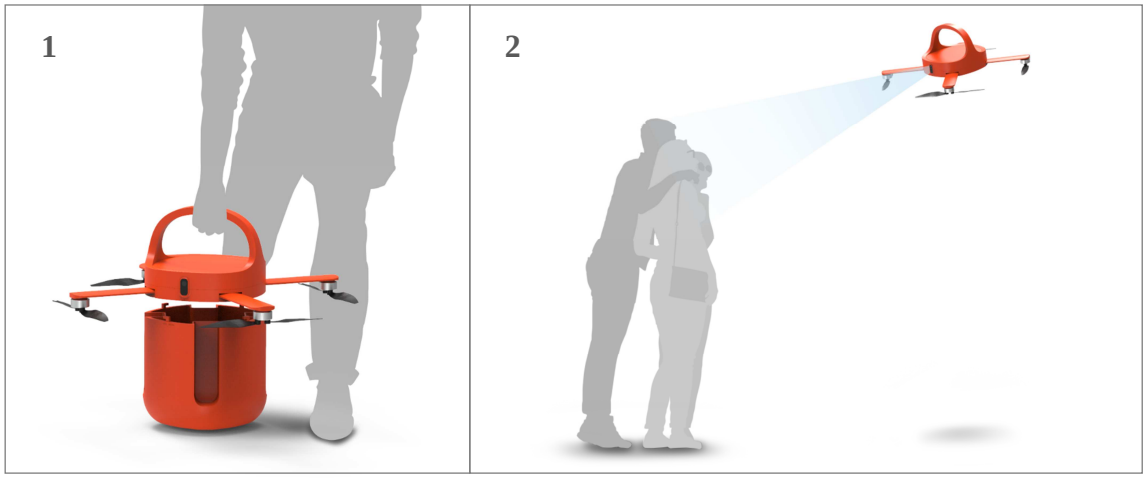

Figure 40. User Scenario of Aerial Photographing

1. The user separates the drone at the top and the container at the bottom.

2. The user flies the drone and takes pictures with friends from any angle he/she wants.

An additional feature of the drone is to support aerial photography. The drone part at the top can be separated and used. The users do not need to carry a separate camera. The user can record an enjoyable picnic experience from any angle without using a selfie stick or setting up a tripod.

5

Conclusion

5.1 Summary

5.2 Limitations

5. Conclusion

5.1. Summary

This study is about development of a concept design of a product that can help carry luggage in the process of a picnic and further provide new picnic experience to users. For this end, picnic tools and products used for the purpose of storing and transporting luggage were investigated. Next, through the empirical study observing user behavior of YouTube picnic vlogs, inconveniences related to luggage carrying were verified and new latent user needs at a picnic were identified. As one of the ways to reflect the issues resulting from the empirical user research into the concept design, inspired by the characteristic of a multi-rotor drone that can be accessed to the spot quickly through the air, a picnic drone that supports luggage carrying and other functions was suggested. Next, the motor and propeller sizes were selected based on engineering data, and this was reflected in modeling and prototyping. In prototyping, detailed folding and fixing structures were implemented and tested. Users can experience a more comfortable and joyful picnic through the concept drone, and furthermore, there is a meaning in this study that it proposes a new short-distance luggage transport method using drones in the future.

5.2. Limitation

This study had the following limitations in the process of proposing a design concept and developing a physical prototype as a final product. There were major three methodological limitations, engineering limitations, and design limitations. If these are solved in future research, a more complete design product will be developed.

- Digital Ethnography: Vlogs correspond to cases within six groups, and it is difficult to see them as an average case representing everyone who enjoys picnics.
- Engineering: It was calculated theoretically based on the motor thrust data of T-Motor company. It is necessary to consider many factors when using it in a real environment such as additional equipment weight, wind and stable output range of the motor etc.
- Design: It was difficult to design folding wings and arms compactly while thinking over the wing safety guard.

6. References

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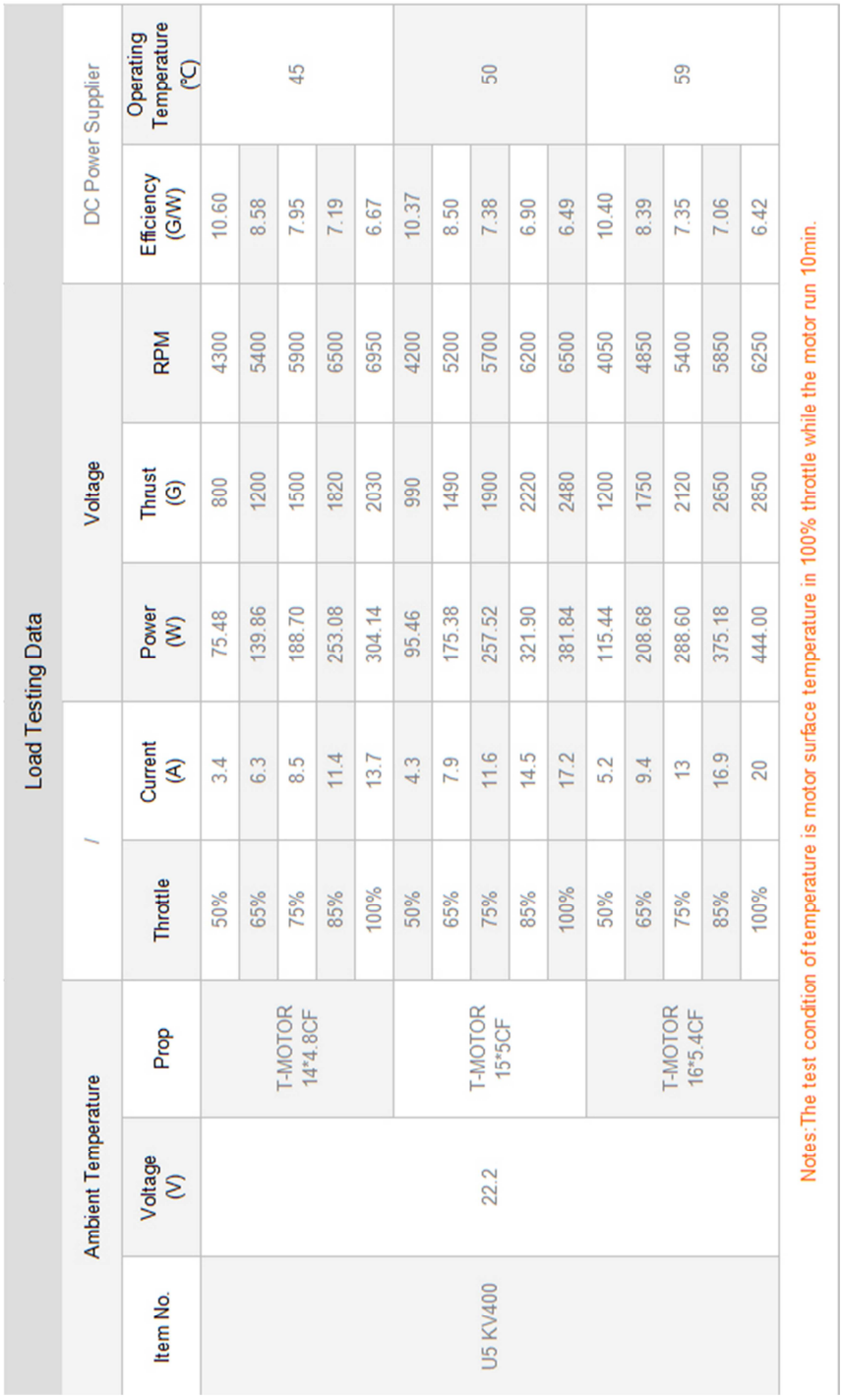
7. Appendices

The table below is the loading testing data according to T-Motor's model. All data was retrieved from T-Motor official website(https://store-en.tmotor.com). Based on the table below, the power consumption can be calculated according to thrust and further derived the required battery weight. A valid combination was found as long as the final weight of the drone with battery does not exceed the thrust of the motor.



Load Testing Data

Item No.	Ambient Temperature	Voltage (V)	Prop	/ Throttle	/ Current (A)	Voltage Power (W)	Voltage Thrust (G)	Voltage RPM	DC Power Supplier Efficiency (G/W)	DC Power Supplier Operating Temperature (℃)
U5 KV400	22.2	22.2	T-MOTOR 14*4.8CF	50%	3.4	75.48	800	4300	10.60	45
				65%	6.3	139.86	1200	5400	8.58	
				75%	8.5	188.70	1500	5900	7.95	
				85%	11.4	253.08	1820	6500	7.19	
				100%	13.7	304.14	2030	6950	6.67	
			T-MOTOR 15*5CF	50%	4.3	95.46	990	4200	10.37	50
				65%	7.9	175.38	1490	5200	8.50	
				75%	11.6	257.52	1900	5700	7.38	
				85%	14.5	321.90	2220	6200	6.90	
				100%	17.2	381.84	2480	6500	6.49	
			T-MOTOR 16*5.4CF	50%	5.2	115.44	1200	4050	10.40	59
				65%	9.4	208.68	1750	4850	8.39	
				75%	13	288.60	2120	5400	7.35	
				85%	16.9	375.18	2650	5850	7.06	
				100%	20	444.00	2850	6250	6.42	

Notes:The test condition of temperature is motor surface temperature in 100% throttle while the motor run 10min.

Load Testing Data									
Ambient Temperature			/		Voltage			DC Power Supplier	
Item No.	Voltage (V)	Prop	Throttle	Current (A)	Power (W)	Thrust (G)	RPM	Efficiency (G/W)	Operating Temperature (℃)
U7 V2.0 KV420	22.2	T-MOTOR 15*5CF	50%	6.1	135	1160	4500	8.57	45
			65%	11.7	260	1870	5700	7.20	
			75%	15.3	340	2260	6300	6.65	
			85%	20.8	462	2690	6850	5.83	
			100%	24.7	548	3030	7250	5.53	
		T-MOTOR 16*5.4CF	50%	7.3	162	1350	4550	8.33	47
			65%	13.6	302	2130	5500	7.05	
			75%	18.6	413	2630	6000	6.37	
			85%	24.2	537	3050	6550	5.68	
			100%	28.7	637	3360	6900	5.27	
	25	T-MOTOR 17*5.8CF	50%	10	250	1940	4500	7.76	51
			65%	18.2	455	2880	5700	6.33	
			75%	25.4	635	3530	6300	5.56	
			85%	32.9	823	4080	6900	4.96	
			100%	39.7	993	4560	7200	4.59	
		T-MOTOR 18*6.1CF	50%	12	300	2250	4200	7.50	59
			65%	22.5	563	3330	5200	5.92	
			75%	31	775	4050	6000	5.23	
			85%	39.8	995	4500	6200	4.52	
			100%	47.5	1188	5060	6700	4.26	

Notes:The test condition of temperature is motor surface temperature in 100% throttle while the motor run 10min.

Load Testing Data									
Ambient Temperature			/		Voltage			DC Power Supplier	
Item No.	Voltage (V)	Prop	Throttle	Current (A)	Power (W)	Thrust (G)	RPM	Efficiency (G/W)	Operating Temperature (℃)
MN3515 KV400	22.2	T-MOTOR 14*4.8CF	50%	3.4	75.48	780	4300	10.33	/
			65%	6.3	139.86	1180	5400	8.44	
			75%	8.5	188.70	1480	5900	7.84	
			85%	11.4	253.08	1800	6500	7.11	
			100%	13.7	304.14	2010	6950	6.61	
		T-MOTOR 15*5CF	50%	4.3	95.46	970	4200	10.16	/
			65%	7.9	175.38	1470	5200	8.38	
			75%	11.6	257.52	1880	5700	7.30	
			85%	14.5	321.90	2200	6200	6.83	
			100%	17.2	381.84	2460	6500	6.44	
		T-MOTOR 16*5.4CF	50%	5.2	115.44	1180	4050	10.22	/
			65%	9.4	208.68	1730	4850	8.29	
			75%	13	288.60	2100	5400	7.28	
			85%	16.9	375.18	2630	5850	7.01	
			100%	20	444.00	2830	6250	6.37	
Notes:The test condition of temperature is motor surface temperature in 100% throttle while the motor run 10min.									

Load Testing Data									
Ambient Temperature			/		Voltage			DC Power Supplier	
Item No.	Voltage (V)	Prop	Throttle	Current (A)	Power (W)	Thrust (G)	RPM	Efficiency (G/W)	Operating Temperature (℃)
MN3520 KV400	22.2	T-MOTOR 15*5CF	50%	4.5	99.90	1010	4280	10.11	50
			65%	8.8	195.36	1540	5400	7.88	
			75%	12.3	273.06	1920	6050	7.03	
			85%	16.6	368.52	2380	6700	6.46	
			100%	20.3	450.66	2700	7100	5.99	
		T-MOTOR 16*5.4CF	50%	5.3	117.66	1140	4160	9.69	55
			65%	10.2	226.44	1780	5260	7.86	
			75%	14.4	319.68	2200	5850	6.88	
			85%	19.4	430.68	2680	6500	6.22	
			100%	23.2	515.04	3000	6800	5.82	
		T-MOTOR 17*5.8CF	50%	6.5	144.30	1340	4000	9.29	67
			65%	12.5	277.50	2120	5000	7.64	
			75%	17.7	392.94	2670	5600	6.79	
			85%	23.3	517.26	3200	6100	6.19	
			100%	28.1	623.82	3600	6450	5.77	
Notes:The test condition of temperature is motor surface temperature in 100% throttle while the motor run 10min.									

Load Testing Data									
Ambient Temperature		/			Voltage			DC Power Supplier	
Item No.	Voltage (V)	Prop	Throttle	Current (A)	Power (W)	Thrust (G)	RPM	Efficiency (G/W)	Operating Temperature (℃)
MN4014 KV330	22.2	T-MOTOR 15*5CF	50%	3.6	79.92	830	3900	10.39	45
			65%	5.9	130.98	1150	4600	8.78	
			75%	7.8	173.16	1430	5100	8.26	
			85%	10.1	224.22	1690	5600	7.54	
			100%	11.9	264.18	1920	6000	7.27	
		T-MOTOR 16*5.4CF	50%	4.3	95.46	950	3700	9.95	50
			65%	7	155.40	1420	4400	9.14	
			75%	9.6	213.12	1750	4900	8.21	
			85%	12.5	277.50	2060	5400	7.42	
			100%	14.7	326.34	2390	5600	7.32	
		T-MOTOR 17*5.8CF	50%	4.7	104.34	1050	3400	10.06	55
			65%	8	177.60	1580	4100	8.90	
			75%	10.7	237.54	1970	4600	8.29	
			85%	14.4	319.68	2300	5100	7.19	
			100%	17	377.40	2600	5400	6.89	
Notes:The test condition of temperature is motor surface temperature in 100% throttle while the motor run 10min.									

Load Testing Data									
Ambient Temperature		/			Voltage			DC Power Supplier	
Item No.	Voltage (V)	Prop	Throttle	Current (A)	Power (W)	Thrust (G)	RPM	Efficiency (G/W)	Operating Temperature (℃)
MN4014 KV400	22.2	T-MOTOR 15*5CF	50%	5.7	126.54	1250	4500	9.88	46
			65%	9.1	202.02	1630	5200	8.07	
			75%	12	266.40	1950	5800	7.32	
			85%	15.8	350.76	2370	6400	6.76	
			100%	18.7	415.14	2620	6700	6.31	
		T-MOTOR 16*5.4CF	50%	6.4	142.08	1410	4200	9.92	53
			65%	11	244.20	1920	5000	7.86	
			75%	14.6	324.12	2380	5500	7.34	
			85%	19.1	424.02	2790	6100	6.58	
			100%	22.5	499.50	3020	6300	6.05	
		T-MOTOR 17*5.8CF	50%	7.6	168.72	1530	4000	9.07	67
			65%	12.8	284.16	2180	4800	7.67	
			75%	16.7	370.74	2550	5250	6.88	
			85%	2.17	48.17	3110	5700	64.56	
			100%	25.7	570.54	3360	6000	5.89	
Notes:The test condition of temperature is motor surface temperature in 100% throttle while the motor run 10min.									

Type	Propeller	Throttle	Voltage (V)	Thrust (g)	Torque (N*m)	Current (A)	RPM	Power (W)	Efficiency (g/W)	Operating Temperature (℃)
MN501S KV240	T-MOTOR P15*5	40%	48.59	1166	0.23	3.57	4887	174	6.72	78 (Ambient Temperature: 9.2℃)
		42%	48.58	1252	0.24	3.89	5067	189	6.64	
		44%	48.58	1319	0.26	4.17	5198	203	6.51	
		46%	48.58	1412	0.27	4.53	5365	220	6.42	
		48%	48.58	1506	0.29	4.90	5536	238	6.32	
		50%	48.58	1605	0.31	5.30	5684	258	6.23	
		52%	48.58	1710	0.34	5.69	5855	277	6.18	
		54%	48.57	1842	0.32	6.26	6057	304	6.05	
		56%	48.57	1949	0.34	6.78	6242	329	5.92	
		58%	48.57	2094	0.36	7.41	6411	360	5.81	
		60%	48.57	2176	0.36	7.87	6513	382	5.70	
		62%	48.57	2199	0.38	8.02	6632	389	5.65	
		64%	48.57	2295	0.40	8.52	6804	414	5.55	
		66%	48.56	2421	0.42	9.11	6960	442	5.47	
		68%	48.56	2557	0.44	9.79	7145	475	5.38	
		70%	48.56	2693	0.47	10.54	7317	512	5.26	
		75%	48.56	3000	0.53	12.32	7729	598	5.02	
		80%	48.55	3294	0.57	14.05	8076	682	4.83	
		90%	48.54	3957	0.70	18.31	8840	889	4.45	
		100%	48.52	4667	0.81	23.11	9532	1121	4.16	

8. Acknowledgement

I finally come to submission of the thesis after my eventful master's course. I would like to express my gratitude to advisor Yunwoo Jeong for guiding me until this thesis was published. Thinking about the thesis together even at late hours and trend reference materials you sent me frequently were very helpful. Also, beyond the thesis, being a researcher at Disegno T9 Lab and having the opportunity to broaden not only knowledge but also design perspective was an irreplaceable and valuable experience. Your professional attitude as a designer and the feedback you gave me had a lot of influence on my growth as a designer. I will engrave in my heart the words “design that contributes to humankind life” which is always said to me, and become a designer with proud as a disciple of you.

In particular, I would like to thank two professors who were in charge of reviewing the thesis despite their busy schedules. Thank professor Huisung Lee, who has always guided me through a separate class so that I could finish my master's thesis safely, and gave me many advices in life. I would also like to thank professor Youngwoo Park who put head together with me when the thesis encountered difficulties and provided insightful feedback. Through the two professors, I was able to understand what research that converges design and engineering is and in which direction it should go.

Also, the fact that there are people walking the same design field gives me the power. I am grateful for our proud members of the Disegno T9 lab, and CDE colleagues who provided productive feedback while preparing for graduation together.

Lastly, I really appreciate my loving parents for always trusting and supporting me. Because of your prayers for me every day and that kind of love, I was able to make it this far, and I was able to decide to go one step further. I will become a proud designer and son who can make a positive impact on society by devoting myself to design research.

This paper was supported by a Korea Institute for Advancement of Technology (KIAT) grant funded by the Korea Government (MOTIE) (P0012725, The Competency Development Program for Industry Specialists)

Sopoong: a New Design Concept for Picnic Activity